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TECHNICAL MEMORANDUM

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 335

SCHÜTTE-LANZ AIRSHIP PROJECTS AFTER THE WAR

By Georg Weiss

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N O T I C E

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By Georg Weiss.

Even during the war, in September, 1916, at the suggestion of the foreign office, Mr. Karl von Wiegand of New York, the then American war correspondent and the present representative of the Hearst press, entered into an exchange of ideas with Professor Johann Schutte and the Schutte-Lanz Airship Construction Company on the technical feasibility of airship traffic with America and on the crossing of the Atlantic Ocean. Ever since that time, the Schutte-Lanz Company has entertained the idea and, after the close of the war has cultivated it intensively by getting into touch with interested American parties.

The interest has nowhere experienced any sudden or unexpected acceleration, but it is nevertheless present in a high degree and is greater than is generally recognized even in aviation circles.

The differences between a war airship and a commercial airship, excepting as regards the passenger accommodations, are little understood by the general public, although they are of a fundamental character. The "S.L.3", built in 1915, and the Zeppelin "L.Z.126" ("Los Angeles"), 1923-4, are respective examples of a war airship and a commercial airship. It would be hardly possible for a layman to tell, from the pictures, which

* From "Schiffbau," May 27, 1925, pp. 313-318.

is the war airship and which is the commercial airship.

The differences are due primarily to the fundamentally different purposes served by these two airship types, and secondly to the extensive theoretical researches made on the basis of the experience with war airships. The present article will therefore deal with a few of the most conspicuous technical points in airship construction.

In the last war airships,* especially for the army, the altitude limit had to be increased by all possible means. This could be accomplished only by the utmost lightening of each structural part and the elimination of all margins, in so far as at all warranted by experience with earlier airships.** With the help of highly refined methods of computation, the working out of which was intrusted by the Schutte-Lanz Company to its first statistician, Dr. Ruehl, the stresses in the framework, finally made of duralumin tubing, were so accurately determined as to render it possible, in extreme cases of loading, to operate with extraordinarily small safety factors (about 1.25), for the main structural parts. Consequently, these high-altitude airships had to be very cautiously handled and painstakingly cared for. Because of their fragility, careful con-

* See article "Starrluftschiff Bauart Schutte-Lanz," by Dr. Ruehl, in Zeitschrift für Flugtechnik und Motorluftschiffahrt, Vol. XII, No. 8.

** See Zeitschrift für Flugtechnik und Motorluftschiffahrt, May 15, 1924, "Leichtkonstruktion des Luftschiffbaus Schutte-Lanz" by Gentzcke, or N. A. C. A. Technical Memorandum No. 313, a translation of said article.

consideration had to be given the weather conditions before starting them on their trips and especially, in bringing them out of or returning them to their sheds. After each voyage, they had to be laid by for quite a long time for the purpose of being overhauled, thereby increasing the cost.

If a commercial airship were built on such a basis, something would naturally give out sooner or later. Considerations of economy demand that commercial airships, like sea ships, shall be able to operate for weeks and even months with only very short periods of rest and without being obliged to return to their sheds. It follows therefore that they must have much greater safety factors and margins in all their structural units. Commercial airships also require a higher degree of safety on account of their passenger service.

In order to save weight in the heavy braced main rings (main transverse frames), cell ends, etc., the cells in war airships were made as long as was consistent, on the one hand, with a favorable shape of the hull and, on the other hand, with the possibility of utilizing the last margins for operating the airship under critical conditions, such as the emptying of a gas bag. Among other expedients on a war airship, the members of the crew, who were not otherwise occupied, were employed for balancing or "trimming" the airship. The case of the emptying of a gas bag on a commercial airship, however, especially in the vicinity of the passenger cabin, produces a

critical situation, since the passengers cannot be handled the same as the crew of a war airship. Even the throwing overboard of the valuable mail must be avoided, if possible. In addition to the employment of stronger materials for the gas bags, the hull must be divided into a larger number of cells than was customary on war airships.

Their thorough investigation of these problems finally enabled the Schutte-Lanz Company to construct bulkhead diagrams for determining the buoyancy of airships, by means of which the size of each cell was established. These diagrams were derived from the bulkhead diagrams employed in ship designing and are used in a similar manner. We will therefore discuss them briefly.

The effect of the emptying of a gas bag, in a previously balanced airship, on the equilibrium and maneuverability of the airship, depends on the size and location of said bag with reference to the center of lift or buoyancy. The lifting power and trim of the airship are hereby affected. The loss in lifting power due to loss of gas must be counteracted either by reducing the load or by dynamic lift or by both means simultaneously. While the airship is flying, the dynamic lift can be utilized. In landing, however, static equilibrium must be restored, in which a decisive part is played by the fuel consumption previous to the landing. Should this be insufficient, superfluous fuel would, under certain conditions, have to be

discharged as ballast just before landing.

The moment obtained by multiplying the local loss in lift by the distance of the center of gravity of the leaky portion from the center of gravity of the airship (In static equilibrium, the centers of gravity and buoyancy lie in the same vertical line), the so-called moment of trim, makes the airship either bow-heavy or stern-heavy, according to the location of the leaky bag, in front of or back of the center of gravity. This moment must likewise be offset by the load or the dynamic air forces, or by both at once in intimate cooperation with the means for taking care of the loss in lift. The remedial measures should generally be so applied as to eliminate the moment of trim first, especially in a bow-heavy condition of the airship, because it might otherwise enter into an unintentional dive and end by striking the ground. The whole problem is greatly complicated by the participation of the effects of the inertia of the mass of the airship, the very complex and variable effects of the dynamic air forces and the fluctuations in the engine power. Hence there is need of very accurate investigation of each cell, much the same as for a submarine boat.

The magnitude of the lifting forces and the counterbalancing moments of trim, which can be produced with the help of the load and the other provisions, can, for any given design, be determined with a fair degree of accuracy by systematic in-

vestigations of all conditions of operation. In this way we obtain certain maximum values for the admissible loss in lifting power at all points along the longitudinal axis, as likewise for the corresponding moment of trim. Neither of these quantities can be safely exceeded by the emptying of the corresponding gas bag. With the help of these values, therefore, the capacity and, consequently, the lengths of the cells can be computed for any point on the axis of the airship. These cell lengths are plotted as ordinates on the airship's axis as abscissas and thus give the bulkhead curve.

A thorough discussion of the calculation of these curves would be too lengthy and we will therefore show, in only one example (Fig. 3) the possible cell lengths for an airship of given shape, by considering only the moment of trim, which, in this example, is assumed to be the same for all the cells. For comparison, there is given in Fig. 4 a cell distribution, which was determined with respect to all the viewpoints mentioned. The moments of trim, which correspond to this distribution of the cells, are also plotted in Fig. 4. These diagrams show in particular that the cells about in the middle of each half are especially critical.

In this connection, it may be remarked that the degree of inflation and the flight altitude of the airship play an important part in the determination of the cell distribution, aside from the disregarded effects of changes in the tempera-

ture and humidity of the air and in the barometric pressure. In a fully inflated airship, the effects of leakage and the remedies, especially the dynamic remedies, required to restore equilibrium, as already explained, are practically independent of the altitude, since both vary according to the density of the air. If, on the contrary, the airship is only partially inflated, the percentile effect of the leakage is smaller than the effect of the available remedies.

These relations are of special practical importance for the case when a leak occurs at a high altitude where the airship is generally fully inflated. As the airship descends, the gas bags shrink with the increasing density of the atmosphere, the degree of inflation of the airship and consequently the rate of leakage becomes smaller, while the remedial means, available in the dynamic power, increase as the density of the atmosphere increases. It follows therefore that the cells can be somewhat longer in airships which fly mostly at a high altitude (like war airships) than in those which only need to fly at a low altitude, the safety in landing being approximately the same in both cases.

The Schutte-Lanz Company calculates the cell enlargement, allowable according to these viewpoints (again borrowing from ship construction), either by employing a factor which somewhat corresponds, in leakage calculations, to the so-called "Flutbarkeit" (ability to float), or by employing a method similar to the different bulkhead curves for different load-lines.

The previously most common practice of making the cells all of the same length was justifiable when the airship had a long cylindrical middle portion, because of the great advantages in the manufacture and assembling of girders of equal length, both for the transverse frames and the longitudinal members, the same as in building ships. This advantage disappears in the now continuously curved meridian line of an airship, as in the "S-L.1," because the length of the girders change from one section to the next.

The creation of new landing and mooring facilities constitutes an important step in the development of airship traffic. During the war, gangs of several hundred men were held in readiness for this purpose. In airship traffic, which must be based on business principles, this method cannot be employed. Numerous experiments in England and America have shown mooring masts to be entirely practical and there will doubtless be further progress in this direction.

One special problem in airship designing was the control of the forces at the mooring point, which have to be regarded as concentrated loads and which are extremely large in comparison with the individual loads formerly involved in airship designing. It must be especially borne in mind that the force at the mooring point can act in any direction and that the maximum values of its components are not in the direction of the airship's axis, but perpendicular to it. This is due to

the fact that, in a sudden change of direction of the wind, the airship requires considerable time to adjust itself correspondingly and in the meanwhile receives the wind laterally. The lateral resistance offered by the airship is from 75 to 100 times as great as in the direction of its axis. Even in a perfectly constant wind, the aerodynamic forces are so distributed that the airship does not stop in the exact direction of the wind, like a good weather-vane. The resulting air force naturally passes directly through the mooring point and its lateral component may be a multiple of the component in the direction of airship's axis and may assume extraordinarily high values in a strong wind or storm.

These great forces, in conjunction with the endeavor to keep the weight of the airship as small as possible, led to avoiding, as much as possible, the use of bent longitudinal girders on the bow of the airship, as had been customary in the previous dome-shaped bows. Thus the front end of the airship again came to have a pointed shape, the same as it had in many of the older designs. It was demonstrated, moreover, that, even with a more pointed bow, a shape can be found which is not inferior to the dome-shaped bow. The sharp bow also has the advantage of making it easier to avoid collision with the mooring mast during landing maneuvers. The mooring mast raises entirely new problems in the reception and discharge of passengers and freight, for which the Schutte-Lanz Company

has likewise worked out a special solution. The traffic does not pass through doors in the vicinity of the mooring point, but over a gangway and drawbridge, which afford the passengers an almost horizontal path from the airship to the waiting room on the mooring mast.

As shown in Fig. 5, the drawbridge and gangway can be brought into position mechanically. The mechanism is, moreover, so constructed that it can yield to the motions of the airship. In order to lessen the time required for unloading, the drawbridge and gangway are built in two stories (Fig. 5), the lower one being entirely inclosed for the passengers, and the upper one being provided with suitable devices for the rapid handling of the freight. Gas, fuel and ballast are taken on through special connections in the vicinity of the mooring point. Easily regulated devices render it possible to maintain the equilibrium of the airship while loading or unloading. Improvements have also been made in the steering gear. Formerly the tail planes were sharply divided into so-called stabilizing planes (fixed) and rudders (movable vertical and horizontal planes). These were all nearly flat and only thick enough to contain the requisite girders. They were held in place by numerous brace-wires. The chief difficulty was to keep their weight as small as possible and this requirement determined their shape.

In the new Schutte-Lanz airships, especially the swifter ones, aerodynamic considerations have come more to the fore.

Rudders and stabilizers are not so sharply divided, but cooperate better, as indicated by the expression "tail-unit," taken from airplane parlance. This manner of construction was rendered possible first of all by the complete elimination of the so-called compensating surfaces. The surfaces of the present tail-unit have, moreover, been made more efficient by giving them more suitable contours and cross-sections and by almost entirely eliminating external bracing. The improvement of their properties rendered it possible to make the tail planes smaller than formerly. This, in conjunction with a better utilization of the construction materials, resulted in the total weight of all the tail planes being hardly any greater than formerly, notwithstanding the greatly increased load per square meter. An example for the future form of the tail-unit is shown in Fig. 5.

This figure, moreover, represents an airship which was especially designed for American conditions. In addition to the differences already mentioned, this project shows a whole series of improvements in connection with the construction of the girder framework, especially in the walkway, and also in the steering gear, the valves, radio system, ballast system, fuel system, navigating instruments, etc.

The passenger accommodations are fundamentally new. The "passenger deck", as indicated by its name, is not simply a cabin suspended from the hull, but is organically combined with

the latter, its external shape conforming to the requirements of minimum resistance to the air.

The interior arrangements of the deck naturally had first to meet the demands imposed by the distance to be traveled and could therefore be greatly modified. How far one could travel with comfort depended ultimately on the result of a profitability calculation, in which the deck weight per passenger was determined for various designs. This enabled the accurate determination of the number of passengers, the fare per kilometer and the accommodations required for the distance to be flown. The total deck weight was found to vary between 80 (176.4) and 300 kg (661.4 lb.) per passenger. The principal characteristics of this airship (Fig. 5) are:

Gas capacity	150,000 m ³	(5,297,175 cu.ft.)
Length overall	266 m	(872.7 ft.)
Greatest diameter	34.25 m	(112.4 ft.)
Engine power	3500 HP.	
No. of propellers	5	
Speed	130 km/hr.	(80.8 mi./hr.)
No. of passengers	100	
Freight capacity	38,000 kg	(83,776 lb.)

Of especial interest is another design (Fig. 6) elaborated by the Schutte-Lanz Company for Arctic research. On the assumption that no other conditions would arise in the polar regions than those already known, this airship did not have to

differ much, excepting as regards the special research equipment, from the airships intended for use in the temperate zones. Other airship traffic projects in the northern hemisphere contemplate crossing the polar regions, because the shortest route is on a great circle. It will be interesting to observe the joining of America and Russia (for example), in this manner.

No serious-minded expedition leader could accept the unrestricted assumption that no unexpected difficulties would arise on polar voyages. Consequently, for this project, recalling the construction and experiences of the "Fram," a much higher safety factor was required for airship and crew than in the case of an airship for ordinary traffic. The greatest danger would be the incrustation of the whole airship with ice. The principal characteristics of this airship are:

Gas capacity	150,000 m ³ , (5,297,175 cu.ft.)
Length overall	263.5 m (864.5 ft.)
Greatest diameter	34.25 m (112.4 ft.)
Maximum engine power	3500 HP.
Maximum speed	130 km/hr. (80.8 mi./hr.)
Radius of action at maximum speed	14000 km (8,700 mi.)
Crew	50

We are not allowed sufficient space for a detailed description of the whole project, but only for a brief mention of the essential features. The radio plant is of prime importance, be-

cause it must be regarded as the only practical means for navigating the polar regions. It consists of apparatus for requesting bearings from distant stations and compass coils for taking bearings from distant stations. For the former method, there is a 2-kilowatt sending set with fan-shaped hanging antenna. For the latter method, there are two compass coils, one being located at the rear end of the airship and the other at the rear end of the passenger deck. To improve the working of the compass coils, these portions of the airship are made entirely of wood without brace-wires, while all the rest of the airship is constructed of duralumin tubing. Provision was also made for the installation of cameras for photographic measurements, the carrying of a rowboat and a small motorboat for use in the event of the airship alighting on water (for example, in deep-sea researches) and, lastly, observation stations at the stern and on top of the hull, which are designed as half-concealed sunken platforms.

As regards the rest of the equipment, it does not differ essentially from that on the regular commercial airship. The question of heating the cabin on polar voyages offers no special difficulty, since the same problem has to be solved for the temperate zones. Electric heating offers the greatest practical advantages and will probably be employed.

Translation by Dwight M. Miner,
National Advisory Committee
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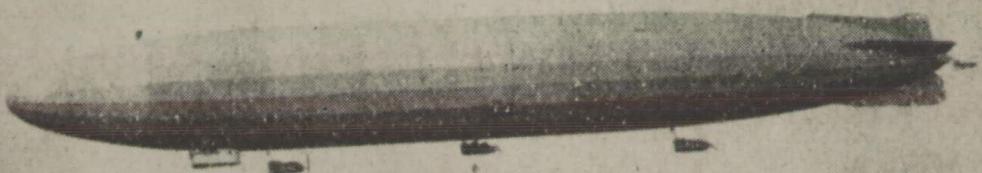


Fig. 1 (S.L. 3)



Fig. 2 (L.Z. 126)

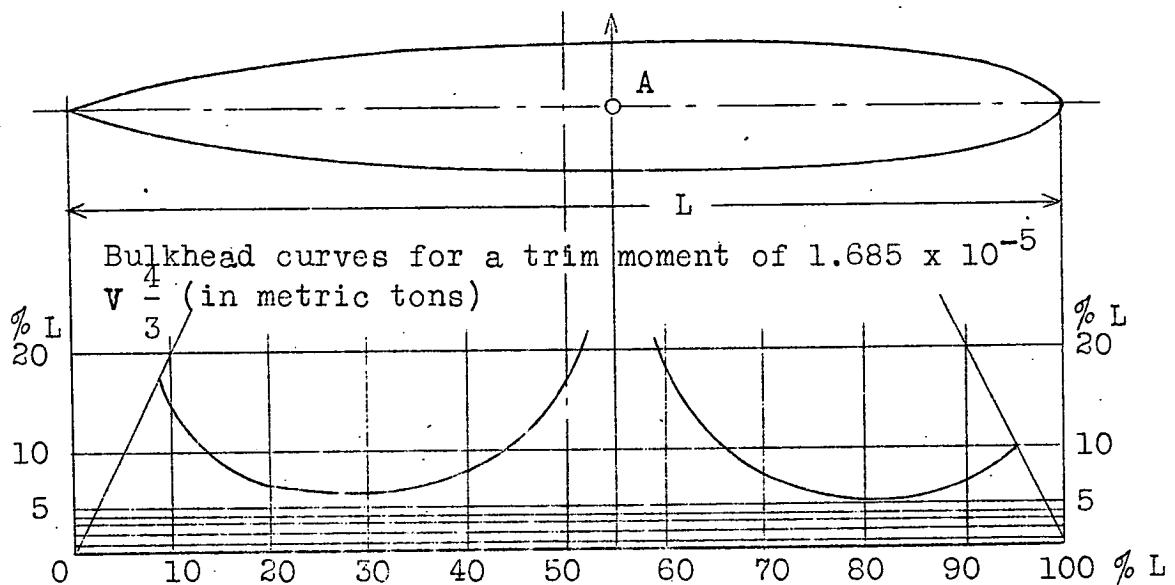


Fig. 3

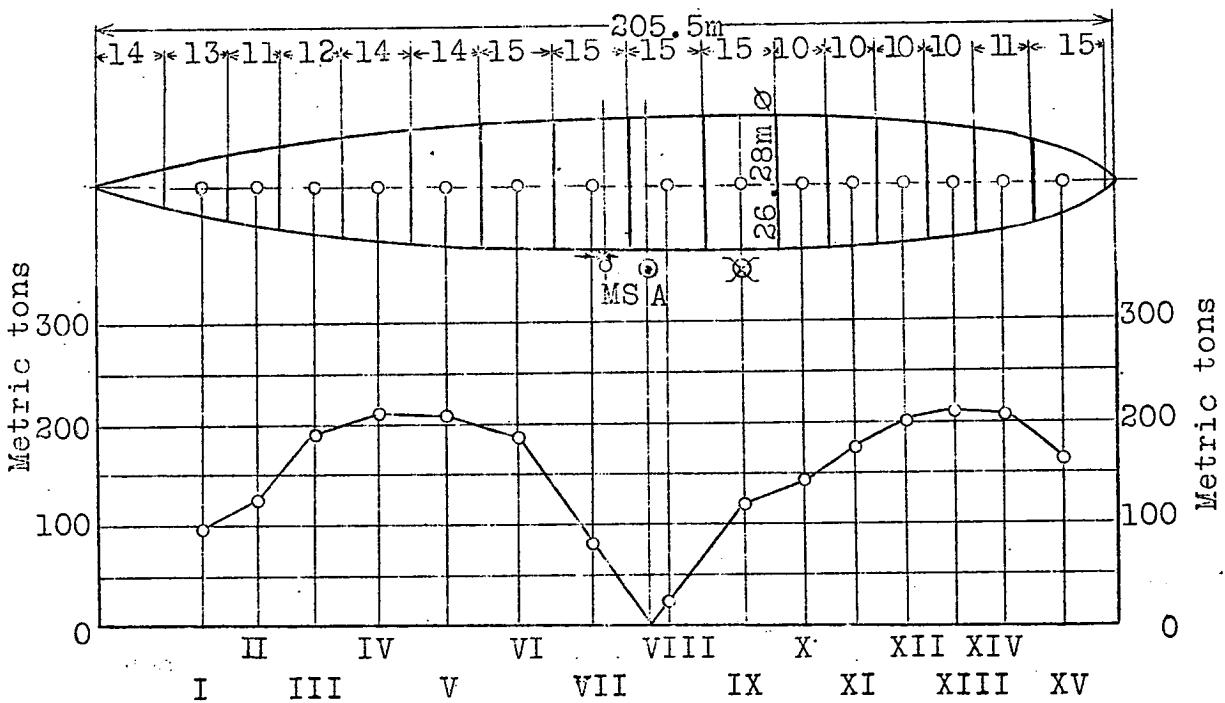


Fig. 4

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Supply pipes.
Service platform.
Mooring-rope windlass.
Service platform.
3-story elevator.
Freight depot.
Waiting room.
Bottom bearing of
revolving head of
tower.

